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A SYSTEMS ANALYSIS OF THE LOGISTICS OF SUPPLYING LETTUCE TO OVERSEAS MILITARY

BY
RICHARD REILLY

UNITED STATES ARMY NATICK
RESEARCH & DEVELOPMENT LABORATORIES
NATICK, MASSACHUSETTS 01760

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report contains an evaluation of the present supply system for shipping lettuce and fresh fruits and vegetables to overseas personnel from the United States west coast, including a determination of logistical problems and spoilage losses in the European and Pacific theaters. The objective of this project was to evaluate methods of transporting lettuce overseas to determine the cost effectiveness of each alternative, based on effective cost per usable case of lettuce shipped. Recommendations contained in this report involve opportunities

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20. Abstract (continued)

to make improvements within the present logistics system base on limited study, and review and analysis of existing data supplied by other Government agencies and commercial firms involved in exporting lettuce.

PREFACE

This technical report describes work conducted under Service Requirement DN 83-14(I), "Systems Analysis of the Logistics of Supplying Lettuce to Overseas Military" and DN 83-14 (II) "Systems Analysis of the Logistics of Supplying Lettuce to Navy Overseas Locations." This service requirement is included in the Department of Defense (DoD) Food RDT&E Program under Project No. 1L162724AH99A and was sponsored first by the Defense Logistics Agency. At a later date, the U.S. Navy cosponsored the project.

The author would like to acknowledge the following individuals for their assistance: Mr. Thomas Hinsch, of the U.S. Department of Agriculture; Mr. Harold Gorfien, of the Food Engineering Laboratory, U.S. Army Natick Research and Development Laboratories (NLABS); and Dr. Lawrence Symington, of the Science and Advanced Technology Laboratory, NLABS.

Mr. Richard P. Richardson, in his former capacity as Program Manager on this project is responsible for much of the early conceptual guidance. Other members of the project team included Mr. George Levesque, Mr. William Chevalier, and Mr. Harry Kirejczyk. These individuals worked diligently in collecting historical literature and data. Their conceptual inputs are also appreciated. Dr. D. Paul Leitch, the current Program Manager and Mr. Philip Brandler, Chief, Operations Research and Systems Analysis Office, NLABS, also made important contributions in reviewing and editing this manuscript.

Unfortunately, exporting of lettuce was curtailed due to reduced supply and demand during 1981-1982, when the shipping test in this project was scheduled. Because the shipping test would be delayed at least one year, the project sponsor decided to withdraw from funding this project. Therefore, the recommendations relate to improvements within the present logistic system and Appendix C contains an experimental design to evaluate cost effectiveness for transporting lettuce to Europe.

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SYSTEMS ANALYSIS OF THE LOGISTICS OF SUPPLYING LETTUCE TO OVERSEAS MILITARY

I. INTRODUCTION

The Operations Research and Systems Analysis Office (ORSAO) of the Natick Research and Development Laboratories (NLABS) was tasked in 1980 by the Technical and Quality Assurance Division, Defense Personnel Support Center (DPSC) to conduct a systems analysis of the logistics of supplying lettuce and other fresh fruits and vegetables to overseas military. This project was initiated to determine more economical ways of providing these commodities to overseas personnel with minimum spoilage losses. In conjunction with the DPSC project, the Navy Food Service Systems Office (NAVFSSO), Washington, D.C., requested in March 1981 that ORSAO extend the scope of work to include supplying fresh lettuce to Navy overseas activities and ships.

Each year the government ships approximately 15 million pounds of lettuce from growing fields in the United States to overseas military installations. Perishable loss reports[1] provided by DPSC indicate that worldwide inventory point spoilage losses range from 6.7 to 10 percent annually. At current market prices, these monetary losses range from $610,000 to $915,000 each year. Those lettuce losses that occur after the product leaves the DPSC inventory point and before it reaches the end-user have not been adequately quantified but have been estimated to add another 5% to 20%. This means the range of the total percent losses that lettuce incurs is 11.7% to 30%. Losses from other perishable produce are less significant but do add to the above figure.

The major factors that affect the delivery condition of lettuce are the excessive travel time between growing fields and final user and inadequate environmental control during shipment and storage. Therefore, a need exists to develop more effective long-distance transportation methods that prevent the deterioration of lettuce quality.

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[1] "Perishable Loss Reports," issued quarterly by the Technical and Quality Assurance Division, Defense Personnel Support Center, Philadelphia, PA

II. OBJECTIVE and METHODOLOGY

This project was conducted to evaluate the present system of procuring and supplying fresh fruits and vegetables to overseas military personnel and to propose more economical ways to provide this service with minimum spoilage losses.

Specific methods investigators planned to use to accomplish this task are as follows:

1. Conduct a cost-benefit analysis of the present method of shipping lettuce and other perishable produce overseas;

2. Identify weaknesses and problem areas in the current system for corrective action;

3. Investigate all factors contributing to spoilage losses in fresh fruits and vegetables shipped overseas;

4. Evaluate alternative methods of transporting perishable produce to overseas bases and determine the most cost-effective method. Implementation of this field test was delayed and thus the project was terminated.

Data Collection

Interviews were held with personnel of different organizations involved in the warehousing and issuance of lettuce. Table 1 lists the numbers of personnel, by organization, who were interviewed. Information concerning procurement, transportation, supply operations, inventory control, quality assurance programs and overseas distribution operations was obtained from Defense Logistics Agency (DLA) managers. For additional information commercial firms and related supporting organizations involved in producing, transporting and preserving perishable commodities were contacted. Samples of data collection forms are contained in Appendix A.

Details of user level operations concerning lettuce receipt and usage were obtained by visiting military commissaries, Troop Issue Subsistence Activities (TISAs) and dining facilities in Germany and England. Table 2 lists the sites and organizations at which representatives contributed to the survey. Discussions were held with the operating managers at each of these facilities.

Table 1
Military and commercial organizations represented in field interviews

Type of Organization

Military

Defense Personnel Support Center, Philadelphia, PA
Defense Subsistence Region - Pacific, Alameda, CA
Defense Supply Office, Bayonne, NJ
Defense Subsistence Region - Europe
U.S. Army - Europe, Heidelberg, GER
Defense Subsistense Region - Europe, Zweibrucken, GER
Defense Supply Office, Felixstowe, GB
Kaiserslautern Cold Storage, Kaiserslautern, GER

Commissaries: Federal Republic of Germany, (four locations)
Great Britain, (six locations)
TISA's (four in Germany)
Troop Dining Facilities (three in Germany, two in Britain)
Post Exchange
Navy Submarine Tender
Veterinary Offices

Commercial

America President Lines (ocean carrier)
Sealand Service Inc (ocean carrier)
Trans Fresh Corp. (tectrol modified atmosphere service)
Growers/Brokers - Associations
Railroad Piggyback Service
Food Source, Inc. (van container with controlled atmosphere)

Table 2
User-level facilities represented in field interviews, Great Britain and Germany

Location	Facilities Visited	Service
Great Britain		
Lakenheath	Commissary - Dining Facility	Royal Air Force
Chicksands	Commissary - Dining Facility	Royal Air Force
Holylock	Commissary	U.S. Navy
Edzell	Commissary	U.S. Navy
Upperhayford	Commissary	Royal Air Force
St. Mawgan	Exchange	U.S. Navy
Dunstable	Commissary Region	U.S. Navy
Germany		
Stuttgart	Commissary - Dining Facility	Army
Fuerth	Commissary - TISA* - Dining Facility	Army
Wuerzburg	Commissary - TISA - Dining Facility	Army
Frankfurt	Commissary - TISA - Dining Facility	Army
Ludwigsburg		
Osterholz	TISA	Army

*Troop Issue Subsistence Activity (U.S.)

In order to evaluate the cost effectiveness of various transportation modes, estimates of freight rates were obtained from air carriers, railroad companies and selected ocean shipping companies. An exploratory questionnaire was prepared and distributed to Navy activities in Pacific and Indian Ocean theaters. The questionnaire (Appendix B) solicited information about the current Navy storage and distribution methods for providing lettuce to ships, commissaries and dining facilities; the quality of lettuce at arrival; facilities and transit delays. Questionnaires were completed in August 1982 and describe the results at that time.

III. CURRENT LOGISTICS SYSTEM

Procurement records provided by DPSC show that an average of 171,500 pounds (4,900 cartons) of lettuce per week was shipped to Europe from 1980 to 1983. For the same time period, the average weekly shipment to the Pacific area was 10,500 pounds (330 cartons).

The process of shipping lettuce to overseas military personnel involves a number of government and commercial activities. The overseas user representative, Defense Subsistence Region-Europe (DSR-E), Defense Subsistence Region - Pacific (DSR-PAC) or Defense Logistics Agency (DLA), initiates the procurement process by submitting a monthly request to the Contracting and Production Division, DPSC. The request is passed on to one of 12 field buyers who have sole responsibility to observe and purchase the lettuce crops with consideration to quality and cost factors. Figure 1 depicts the logistics chain that begins at the growing fields with the DLA-DSR-E order.

The logistics chain for supplying Navy consumers in the Pacific is much less complex than for European supply points. Navy users in the Pacific submit a monthly request to the Contracting and Production Division (DSR-PAC) in Alameda, CA. Produce is procured, shipped to the vacuum cooler and transported by truck to West Coast shipping points. From there it is shipped by ocean carrier to Naval Supply Centers at Pearl Harbor, Yokohama, Diego Garcia, Guam, Subic Bay and other stations for storage and then distribution to ship and shore installations.

Harvesting and Loading

The harvested lettuce is packed in cartons at the field either in plastic wrap or "naked" (without wrap) and brought to the nearest vacuum cooling facility in flatbed trucks. The facility usually receives the lettuce within one-half hour from the time it is picked in the field and through a vacuum cooling process, brings the average lettuce temperature down to 34°F in about 15 minutes. During the vacuum cooling and conveyance loading process, a USDA inspector is available to check the grade of lettuce, pulp-temperature and conveyance opening temperature. For Pacific shipments lettuce is also inspected for acceptance at this point since no transloading is required at the seaport. The cooled lettuce is then loaded into refrigerated trailer trucks if destined for the eastern seaport, or into ocean van containers if the shipment is to depart to the Pacific theater from the western seaport.

The capacity of trailer trucks is 800 cartons of lettuce. Fortyfoot van containers hold 503 cartons, and the newer 45-foot van containers being integrated into the system carry approximately 650 cartons.

Ocean Delivery to Central Storage Facilities

The ocean carrier sails from Portsmouth to Bremerhaven, Germany, where all lettuce scheduled for distribution in Germany and Italy is off-loaded (see Figure 1). One lettuce container remains on the ship and is transferred to a secondary carrier in Rotterdam, Holland, for delivery to England (see Figure 2). Lettuce off-loaded in Bremerhaven passes through German customs and is hauled to the U.S. Government central cold storage in Kaiserslautern, Germany, by railroad piggyback and truck chassis to and from the railheads.

The lettuce scheduled for delivery to England remains on the ocean carrier sailing to Rotterdam, Holland. At Rotterdam the single van container is transferred to a secondary feeder carrier that sails to England. Lettuce off-loaded at the Felixstowe port passes through British customs and is hauled by truck chassis to the U.S. Government central cold storage in Felixstowe.

Overseas Storage and Distribution

Shipments of lettuce arrive at each central cold storage once per week in Europe and biweekly at Pacific supply points. There they are examined for quality before being transferred to the chill storage area(s). Temperatures in chill storage rooms are typically kept at 38°F.

DLA customers in Germany (commissaries and TISAs) receive deliveries twice weekly and in England (commissaries and troop dining facilities) delivery is usually once per week. Transportation of lettuce is arranged by the central storage facility using refrigerated trucks except that lettuce shipped to customers located in Berlin, Germany, is sent by rail.

There are approximately 74 DLA customers in Germany and Italy serviced by Kaiserslautern. Twelve of these customers are TISA's supplying central subsistence support for troop issue. Because the TISA does not have provisions to transport subsistence, all customers must make their own pick-ups. Pick-ups are usually made with open, non-refrigerated trucks that may travel up to 50 miles between the dining facility and TISA. Felixstowe services 17 customers in Great Britain with all deliveries made by refrigerated truck.

TOTAL TRANSPORTATION SYSTEM
SHIPPING LETTUCE TO GERMANY

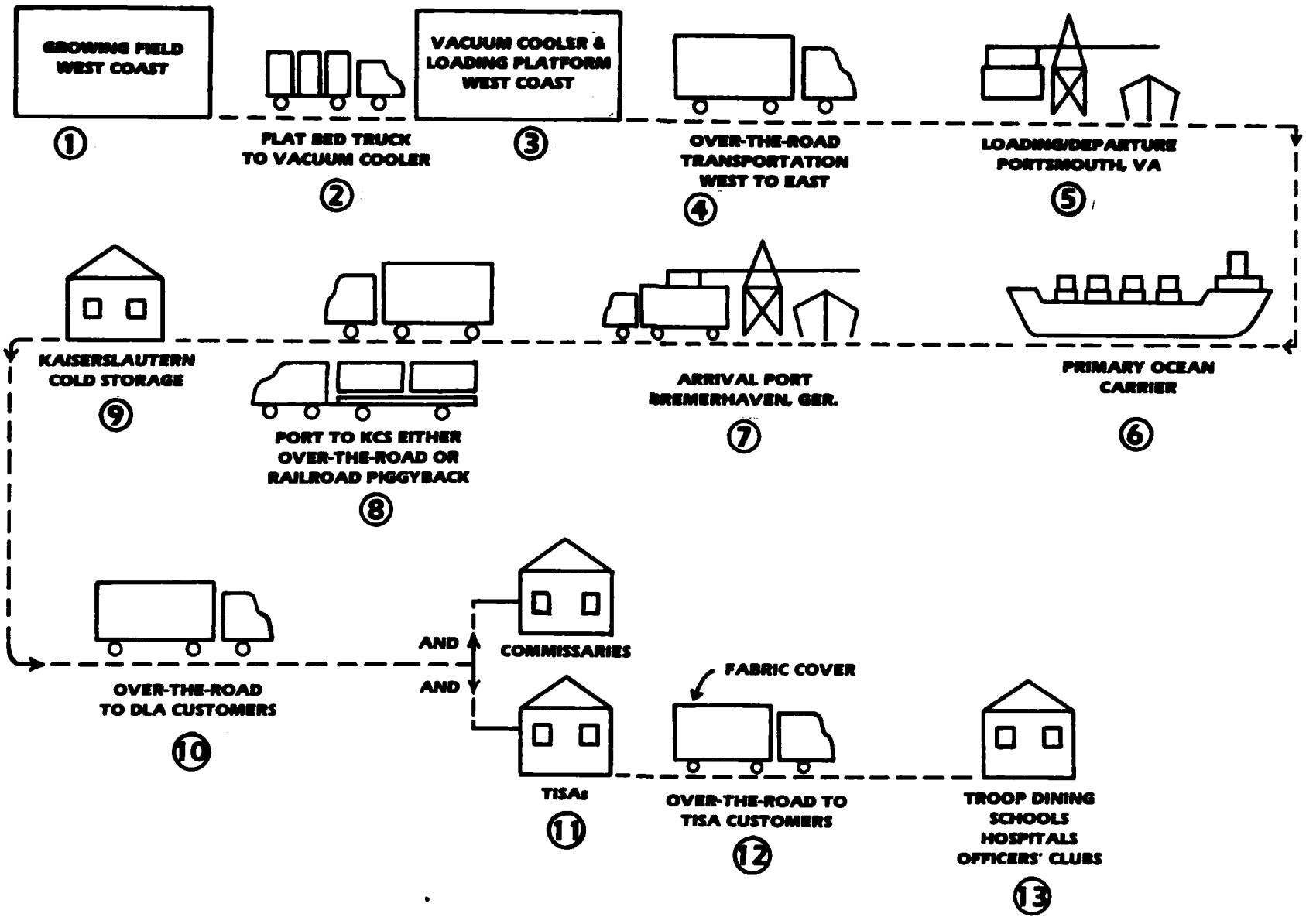

FIGURE 1

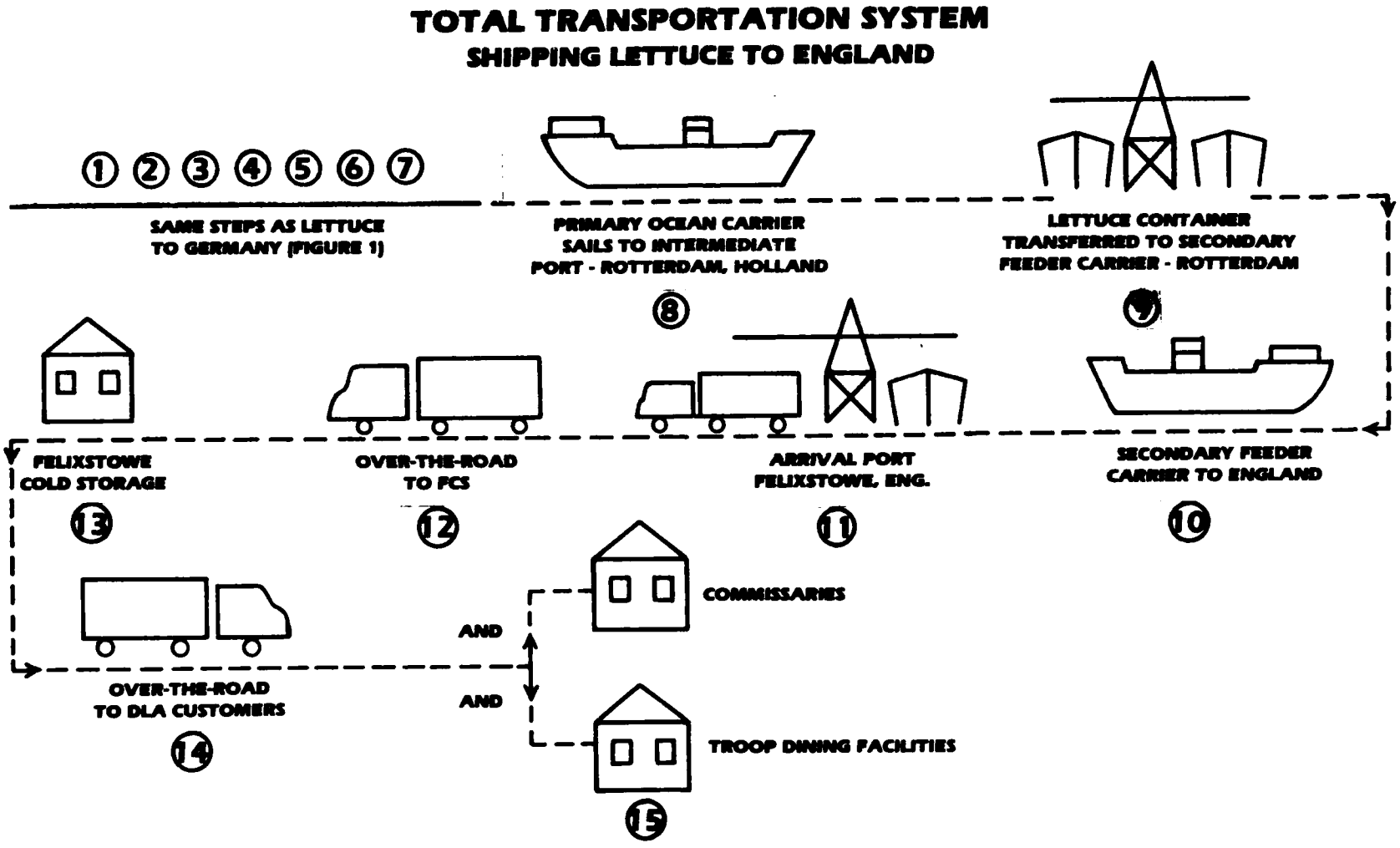
TOTAL TRANSPORTATION SYSTEM
SHIPPING LETTUCE TO ENGLAND
① ② ③ ④ ⑤ ⑥ ⑦
SAME STEPS AS LETTUCE TO GERMANY (FIGURE 1)
PRIMARY OCEAN CARRIER SAILS TO INTERMEDIATE PORT - ROTTERDAM, HOLLAND
⑧
LETTUCE CONTAINER TRANSFERRED TO SECONDARY FEEDER CARRIER - ROTTERDAM
⑨
FELIXSTOWE COLD STORAGE
⑬
OVER-THE-ROAD TO PCS
⑫
ARRIVAL PORT FELIXSTOWE, ENG.
⑪
SECONDARY FEEDER CARRIER TO ENGLAND
⑩
COMMISSARIES
AND
AND
OVER-THE-ROAD TO DLA CUSTOMERS
⑭
TROOP DINING FACILITIES
⑮

FIGURE 2

IV. RESULTS AND DISCUSSION

Transit Times

Observations of the delivery process, inspection reports, and discussions with supply personnel provided data on the actual time it takes for lettuce to reach the consumer. Table 3 presents the expected and average observed lengths of time for delivery from the west coast to overseas users in Germany and Great Britain. Under the current system, the minimum expected transit time is approximately 25 days. From the data collected, the longest delivery time was 46 days. Under this worst-case condition, the lettuce probably would be unusable upon reaching the consumer. The USDA[2] suggests that the storage time for good quality lettuce is two to three weeks at 32°F. Therefore, even with the minimum transit time the lettuce would be at the end of its expected shelf life.

Lettuce Spoilage Losses

Lettuce spoilage losses were derived from data in perishable loss reports[3] issued by the Quality Assurance Division, DPSC and discussions with operating managers of commissaries, TISAs and dining facilities in Great Britain and Germany. Table 4 shows arrival, in storage, and total lettuce spoilage losses by year, at overseas cold storage areas. Table 5 presents combined estimates for arrival and in-storage losses at user-level facilities. Supply personnel at DSR-E estimate that lettuce losses at Kaiserslautern Cold Storage (KCS) range from 5% to 15% annually. Also, Troop Support Agency personnel who coordinate commissary operations in Germany estimate that most commissary stores realize an average annual receipt and in-storage spoilage of 30%.

Cross-Country Transportation Modes

Through data collected in field interviews and information obtained from the literature, the following observations regarding the trucks currently used to ship lettuce cross-country are made:

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[2]"The Commercial Storage of Fruits, Vegetables, and Florist and Nursury Stocks," U.S. Department of Agriculture, Handbook 66, U.S. Government Printing Office Washington, DC, August, 1977.

[3]Perishable loss reports. Quality Assurance Division, Defense Personnel Support Center Philadelphia, PA, (1978 thru 1981)

Table 3
Approximate time for lettuce shipments from grower to end-users, Germany and Great Britain

	Expected Time	Observed Time Delays	
		Average	Range
	(Hours)	(Hours)	(Hours)
Field to Vacuum Cooling Area *	1	1	1-2
	(Days)	(Days)	(Days)
Highway Truck Loading	½	1	½-1
West to East Mini-Bridge	4	4½	4-5
Transloading/Load Aboard Ship	½	1	1½-1
Ocean Voyage	10	11	10-12
Off Loading to Kaiserslautern Cold Storage Arrival or Ocean Voyage to Rotterdam and Off-Load, Transit to Felixstowe, GB	2	2½	2-3
Kaiserslautern Cold Storage Arrival Into Chill Storage	2	4	2-8
Time in Storage	2	7	2-15
Storage to Defense Logistic Agency Customer	1	3	2-4
Customer Holding Time **	3	1½	1-2
TOTAL	27	38½	27-55

* Does not include time between harvesting and truck loading.

** Commissary and TISA's only (dining facilities are supported by TISA's adding 3 to 4 more days).

TABLE 4
Assessment of lettuce losses at overseas central cold storage areas by year (% of total lettuce received)*

	1978	1979	1980	1981
Worldwide:				
Arrival	5.7%	10.2%	5.1%	6.6%
In Storage	2.9	1.6	1.1	1.4
Total	8.6	11.8	6.2	8.0
Europe:				
Arrival	6.2	16.0	5.3	9.0
In Storage	4.5	3.5	1.6	1.1
Total	10.7	19.5	6.9	10.1
Kaiserslautern, GER:				
Arrival	5.5	12.7	5.4	10.5
In Storage	5.1	3.0	1.9	2.9
Total	10.6	15.7	7.3	13.4
Felixstowe, GB:				
Arrival	2.2	17.1	11.1	11.4
In Storage	NA	0.7	0.8	0.0
Total	2.2	17.8	11.9	11.4
Pacific:				
Arrival	4.5	8.25	4.7	2.5

* Percent losses represent reports from arrival and in storage condition at central cold storage. Losses at the user level have been estimated to be an additional 5% to 20%.

Table 5
Assessment of lettuce losses at user-level facilities
(% of total lettuce received)

	Commissaries	TISAs	Dining Facilities
Lakenheath, GB (RAF Base)	4%-8%		30%
Chicksands, GB (RAF Base)	10%		
Edzell, GB (Navy)	30%		
Stuttgart, GER (Kelly Barracks)			25%-50%
(Patch Barracks)	8%-12%		
Wuerzburg, GER (Fuerth-Johnson Barracks)	10%	10%	
(Darby Barracks)			25%
(Layton Barracks)	25%	15%	25%-50%
Ludwigsburg - Osterholy, GER		10%-15%	
Grussamhien Kaserne		25%	
Fliegerhorst, GER (JFK Dining)			20%
Frankfurt, GER	12%		

1. Because most highway trucks are designed to carry dry goods, they do not have suitable insulation or a sufficient refrigeration capacity to maintain the required holding temperature for chilled produce.

2. It was reported many trucks used to haul lettuce have moderately to severely damaged walls, floors or doors. Therefore, they are not able to maintain the required internal holding temperature for lettuce. However, of six commercial trucks seen by the research team in field visits, only one vehicle showed such damage.

3. Many trucks do not use front or rear bulkheads to allow proper air circulation.

4. Trucks are not adequately precooled prior to loading.

Other factors that contribute to the deterioration of produce during cross-country transit are identified in "Factors Affecting Transit Temperatures in Truck Shipments of Fresh Produce."[4] In addition, this publication suggests corrective actions necessary to improve the delivery condition of lettuce and other perishable commodities.

Off-Shore Buying

Purchasing iceberg lettuce off-shore from European growers has been investigated as an alternative to shipments from the west coast. This is not a new approach, since a portion of iceberg lettuce consumed on military bases during the summers of 1979 through 1982 was purchased locally in Holland, Italy and Spain. By purchasing lettuce off-shore, considerable savings in transportation charges, and spoilage loss costs would be realized. However, in Europe sufficient quantities of iceberg lettuce are not available to supply all military users. Primarily because iceberg lettuce was not grown in Europe prior to being introduced by U.S. growers, local growers are not able to supply enough to meet demand. In addition, the growing season in Europe, except for that of Spain, runs only mid-May to mid-October. Periods of heavy rain or humid weather conditions common in Europe may also severely hamper lettuce output. Therefore, besides the need to supply U.S. grown lettuce during the fall and winter, backup supplies may be necessary for the summer season.

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[4]Robert F. Kasmire and R. Tom Hinsch. "Factors affecting transit Temperatures in Truck Shipments of Fresh Produce." U.S. Department of Agriculture, Marketing Research Report, Market Quality & Transportation Research Lab, Fresno, CA, in press.

An open procurement policy permits DSR-Europe to buy all their lettuce needs off-shore when available instead of receiving lettuce shipments from the continental United States. A particular concern with off-shore buying is business lost by U.S. growers that was reported to be $200,000 during the 1982 summer season.[5]

Prepackaged Lettuce

The issue of whether wrapping lettuce in plastic film will add to the shelf-life and be cost-effective has been a controversy for a number of years. Results from a limited number of experimental shipments of wrapped and naked heads of lettuce show that the estimated cost of prepackaging is $1.50 per carton, including the extra labor and materials. This cost is offset to some extent in that the outer leaves of the lettuce are removed prior to prepackaging, reducing the weight of each carton by 10 to 12 pounds, and resulting in reduced transportation charges.

Controlled Atmosphere Service

Controlled or modified atmosphere service consists of various mixtures of gases that replace the normal atmosphere within the transit vehicles. This serves to extend the shelf-life of produce by slowing its respiratory rate thus delaying the ripening process. A controlled atmosphere signifies a constantly monitored and replenished gas mixture. A modified atmosphere consists of a gas mixture that is applied once and is then maintained by the air tightness of the transit container. The process involves flushing out most of the oxygen and replacing it with another gas mixture that is predominantly made up of nitrogen.

For a nine-month period from April through December, 1980, the Quality Assurance Division, DPSC, monitored experimental lettuce shipments from the east coast to Europe in order to evaluate the effectiveness of a modified atmosphere service. By determining the arrival quality of lettuce at its destination point, the capability of modified atmosphere to extend the shelf life of lettuce was compared to normal atmosphere. DPSC recommendations, based on the results of the experiment, were to discontinue modified atmosphere service and to conduct side-by-side cost-effectiveness evaluations of the use of modified atmosphere with Pacific shipments. The staff at NLABS reviewed the data and the results from the experiment and made the following observations.

---

[5]The Packer Newspaper, Shawne Mission, Kansas, 21 August 1982.

1. The quality of the lettuce in the experimental shipments was not noted during loading and transporting, except to determine if lettuce met U.S. #1 Grade or better.

2. Of the 35 experimental shipments consisting of 239 van containers, only 7 shipments contained paired samples of both modified and normal atmospheres.

3. Lettuce shipped from both the west and east coasts was included in some of the same shipments.

4. Time delays from the European arrival port until inspection at the Kaiserslautern cold storage area varied from 2 to 15 days with an average delay of 7 days. This variation in time delay occurred even among lettuce van containers arriving on the same ship.

5. Arrival temperatures often were reported to be higher than the desired holding temperature. No consideration for temperature variation was made when comparing quality of lettuce.

Based on the above observations, staff members at NLABS concluded that failure to control key variables biased comparison of transportation modes. Further testing is recommended since there does not appear to be sufficient data to determine whether shipping lettuce overseas using a modified or controlled atmosphere will extend shelf life.

Unitized Shipments

Unitized shipment consists of lettuce cartons bound together in a single unit on pallets or slipsheets. The units would be handled and loaded by mechanized lift truck instead of the current method of manually loading and hand stacking individual cartons. The following benefits would be derived by using unitized loads during transit and storage:

1. Faster loading, transloading and off-loading unit loads will lessen labor costs at central warehouses and port terminals;

2. Mechanical damage such as that which occurs from forklifts in the manual loading and unloading of lettuce cartons would be avoided;

3. Shipments can be loaded and transloaded more rapidly, reducing the time spent outside the refrigerated areas.

Despite these benefits, discussions with supply and transportation personnel and user-level managers reveal that conversion to the unit load method of shipment requires a considerable amount of funds for equipment and facility modifications. For example, many overseas bases would need to purchase mechanized lift trucks. Most storage warehouses do not have the adjustable loading docks necessary to accept different truck designs. Most chilled storage spaces, as well as most delivery trucks, have 30-inch doorways that will not pass standard pallet loads. Finally, most DLA customers take less than one unit load of lettuce (that is, one pallet).

Air Cargo Transportation

Flat-rate charges of $28.10 and $24.50 per carton of lettuce shipped from the west coast to Europe were obtained from two air freight companies. The drayage cost from the growing field to the airport and from the airport to overseas cold storage facilities was estimated at $3.00 per carton, bringing the total cost for air cargo transportation to approximately $30.00 per carton. The cost of using surface transportation was determined to be about $15.00 per carton. No further analysis was conducted, because spoilage losses using surface transportation do not exceed the $15.00 per carton needed to make air transportation a breakeven alternative, even when assuming that air transport would incur no spoilage losses.

Transportation to the Pacific

The above results have pertained primarily to shipments to European supply points and reflect the fact that most of the data was gathered with Europe in mind. Results were, however, obtained from a survey sent to U.S. Navy Supply Officers in the various Pacific produce receiving stations. These results are summarized in Table 6.

Perhaps the most obvious pattern in the results from the Navy survey is that spoilage losses are not so severe a problem as those associated with European shipments. Most of the Supply Officers completing this form reported that the quality of the lettuce when received was "good" to "excellent." The two exceptions to this pattern may be significant, however, because they are from the two largest Supply Centers: Guam and Yokohama. The reported loss rates at Guam, from 0-10%, are similar to those reported from European storage centers. Thus, while the Navy may not have as pervasive a problem in the Pacific, some losses are incurred and improvements for shipping lettuce may be beneficial to both the Pacific and the European users.

Considering that shipments to Europe averaged approximately 4,900 cases weekly (from 1980 through 1982), the shipments to Navy Supply Centers in the Pacific are extremely small in comparison, the average being 330 cartons per week in the same time period. As shown in

Table 6, the Navy's shipments are sometimes mixed cargo. Shipments to Europe, however, are not mixed loads. Thus, it is clear that Europe represents the greater opportunity for realizing tangible benefits from improved methods of shipping lettuce.

TABLE 6
U.S. Navy produce shipment and storage problems

	Cartons Received Bi-weekly	Quality	Type Storage	Time-Delay Port to Storage	Time in Storage	Mixed Produce Shipments
Yokohama Cold Storage Facility	364	Fair	Central Cold Storage	2 days	3-10 days	Yes
U.S. Navy Office Singapore	No U.S. Lettuce received. Local source by contract or blanket purchase agreement.					
U.S. Navy Supply Center- Pearl Defense Supply Office Storage Facility Veterinary Activity	1-2 vans per year	Good	Central Cold Storage	4 days	5 days	No
Naval Supply Depot Guam, M.I.	600	0-10% occasionally 75%-100%	Central Cold Storage	1 day	1-14 days	No
Naval Supply Depot Subic Bay R.P.	276	Generally Good	Cold Storage	Lack of Storage 1-5 days	1-30 days	Yes
Task Force 73 Subic Bay,R.P.	0	Good to Excellent	Cold Storage	1 day	0	Occasionally
Naval Supply Facility Diego Garcia (British Indian Ocean	225	Excellent	Cold Storage	20 minutes	1-3 days	Yes

V. SUMMARY AND RECOMMENDATIONS

This systems analysis attempted to identify those areas in the present logistics system where improvements could be made to transport more efficiently perishable produce overseas. Based on this analysis, the following recommendations are made.

1. More intensive management control should be exerted to reduce the delays involved in moving lettuce from one mode of transport to another, and in moving the product from the port of arrival to the central storage facility.

2. DPSC specify that U.S. Department of Agriculture-design van containers and trailer trucks be used for all lettuce that is to be shipped overseas.

3. Proper lettuce storage temperatures be maintained at military activities to help reduce spoilage at the user level. This might be achieved by providing a separate lettuce storage space.

4. A direct distribution system be implemented, on a trial basis, to deliver lettuce from the arrival port directly to user activities.

5. A rigorous field experiment as described in Appendix A be conducted to define the spoilage losses at each stage of handling in the current system and to evaluate a potentially more effective method for shipping lettuce to overseas users. The experimental design for shipping lettuce from the United States West Coast to Europe developed by the Operations Research and Systems Analysis Office at NLABS is reproduced as Appendix C.

As has been pointed out in earlier sections of this report, the existing data and prior analyses of spoilage losses and shipping methods are far from conclusive. Previous studies have not used adequate experimental controls to isolate the causes of spoilage losses. The analyses reported in this note have proceeded as far as is possible with the existing data base. New data derived from a controlled field study is now required if improvements to the existing system are to be firmly grounded in fact.

This document reports research undertaken at the U.S. Army Natick Research and Development Command and has been assigned No. NATICK/TR-83/039 in the series of reports approved for publication

APPENDIX A. Data Collection Forms

Inspection Date_____

In addition to quality and/or conditon data from inspection certificate FVQ Form 184-1, the following data is required.

PRODUCT DATA:

Lettuce Variety: Cultvar type_____

Environmental Conditon/Temperature: At Harvesting_____, Loading_____

Packaging Mode: Naked, No. Cartons_____, wrapped, No. Cartons_____

Cartons: Size_____, Type_____

Loading Method: Individual Cartons_____, Pallets_____, Slip Sheets_____

Lettuce Cost (at vacuum cooler): Per Carton_____

TRAILER/VAN CONTAINER DATA:

Carrier Type: Trailer_____, Van Container_____

Carrier Ident: _____

Floor Type: Flat_____, Extruded Groove_____, T-Beam_____

Side Walls: Flat_____, Recessed Grooves_____, Protruding Ribs_____

Front Bulkhead: None_____, Makeshift_____, Manufactured_____

Air Delivery: Top Air Flow_____, Bottom Air Flow_____

Precooled Temperature (Inner Surfaces): _____

Atmosphere: Normal_____, Modified_____, Controlled_____

Transportation Cost (West to East): _____

FIGURE A-1. West Coast Segment Data Sheet

Inspection Date_____

In addition to acceptance criteria data from the Veterinary Field Office track sheet MED-V 134, the following data is required.

PRODUCT DATA

Lettuce Condition: % Spoiled_____

Type of Defect: Decay/rot_____, Insects/Rodents_____, Freeze_____

Penetrating Mold_____, Spotted/Russeting_____,Mechanical_____

Pink Rib_____

Transloading Method: Manual_____, Machine_____

OCEAN VAN CONTAINER DATA

Container Type: Sealand 35'_____, Sealand M-10_____, Food Source_____

Precooled Temperature (Inner Surface): _____ ^{o}F

Container Condition: Undamaged_____, Some Damage_____

Traceability: Trailer Ident No._____

Van Container No._____

Drayage Cost (East Coast)_____

Ocean Voyage Cost_____

FIGURE A-2. East Coast Segment Data Sheet

Inspection Date_____

In addition to arrival condition report data, DD Form 1691, the following data is required.

CONTAINER DATA:

Atmoshphere at inspection: Oxygen Level %_____

DRAYAGE COST (Arrival Port to KCS)

FIGURE A-3. European Segment Data Sheet

Start Date_____

Shipping Alternative_____

Condition Inspection	Date	Sample Size	Cold Room Temp	Lettuce Pulp Temp	Lettuce Net Wt. Lbs	Adjusted Net Wt. Lbs	Spoilage Loss Wt Lbs	Consumable Lettuce Wt Lbs	Spoilage Loss %
Initial		10 ctns							
3rd Day		10 ctns							
6th Day		10 ctns							

Lettuce Net Wt. - Total weight of lettuce less carton (ctn)

Adjusted Net Wt. - Weight of lettuce less wrapper leaves (all leaves outside Cap leaves).

Spoilage Loss Wt. - Weight of inedible lettuce, ie. inner leaves with defects materially affecting appearance and/or edible quality

Consumable Lettuce Wt. - Lettuce, remaining after removing spoilage loss weight.

FIGURE A-4. Spoilage Data Summary Sheet

APPENDIX B. NLABS Questionnaire: Lettuce Shipment Overseas

NLABS QUESTIONNAIRE

LETTUCE SHIPMENTS OVERSEAS

The following questions pertain to shipping US grown iceberg lettuce to Navy overseas installations. Please answer all questions that relate to your specific operation regarding storage and transporting lettuce.

I. GENERAL INFORMATION

A. Installation: _____

B. Location: _____

C. Supply Officer: _____

1. Address: _____

2. Telephone: (Commercial) _____ (Autovon) _____

D. Point of Contact for Additional Information:

1. Name: _____

2. Title: _____

3. Address: _____

_____

4. Telephone: (Commercial) _____ (Autovon) _____

II. RECEIVING LETTUCE

A. Unloading Port: _____

B. Cartons of Lettuce Received Weekly: _____

C. How Often is Lettuce Received: _____

D. Where is Lettuce Inspected: _____

By Whom: _____

E. How is Inspection Performed:

1. Sample Size: _____

2. Procedure: _____

3. How is Quality of Lettuce Received:_____

F. Where is Initial Delivery Point (Check one):

1. Central cold storage_____

2. Non-refrigerated storage_____

3. Commissary and/or dining facility _____

4. Other _____

G. Are Lettuce Shipments Received/Made with Other FF/V in same Van Container: _____

H. How is Lettuce Transported to Initial Delivery Point (check one):

1. In original van container ____

2. In refrigerated vehicle _____

3. In non-refrigerated vehicle _____

4. Other (describe) _____

I. Indicate Time Delay (days or hours) from Unloading Lettuce from Ship Until it Arrives at Storage Area:_____

J. How Often is Lettuce Delayed In-Transit from Port to Storage Area (times/month):_____

K. What are Reasons for the Delays (check one):

1. Lack of storage space_____

2. Inspection delayed_____

3. Other (describe)_____

III. LETTUCE STORAGE

A. Is Adequate Cold Storage Always Available:

Yes_____ No_____

B. What is Number of Day(s) Lettuce is Held in Storage Before Distribution to User:

Minimum_____ - Average_____ Maximum_____

IV. Where are the End Users (Ashore, EDF's, Ships, etc.) and what is Expected Time from Ship Unloading to Usage:_____

_____

V. Submitters are requested to provide additional beneficial comments or background data that can be used to evaluate the current logistic system for shipping and handling lettuce shipped overseas for the purpose of making improvements.

APPENDIX C.
Experimental Design for Shipping Lettuce From West Coast to Europe

I. OBJECTIVE

To collect necessary lettuce spoilage data to evaluate the cost effectiveness of six alternative methods for transporting lettuce from the CONUS West Coast to Europe.

II. EVALUATION CRITERIA

The cost effectiveness of each alternative will be based upon effective cost per usable case of lettuce, defined and determined as follows:

$$EC_i = \frac{L + T_i}{(1 - Pi)} \quad \text{, for i = alternatives A, B, C, D, E, F.}$$

EC_i = Effective cost per usable case for alternative i.

L = Cost of a case of lettuce

Ti = Transportation cost per case of lettuce from CONUS West Coast to Kaiserslautern for alternative i.

Pi = Cumulative percent spoilage by weight for alternative i for three different points in time.

To evaluate the cost effectiveness of alternatives, spoilage data must be collected down to the final consumer levels. The method for collecting this data will be discussed later.

III. ALTERNATIVES TO BE EVALUATED

Six alternative methods for transporting lettuce from the CONUS West Coast to Europe will be evaluated. No air transport alternatives are included in this evaluation. For all alternatives the lettuce will be precooled prior to being loaded into the container/van at the CONUS West Coast. Each of the six alternative methods, denoted Alternative A through Alternative F are described below.

ALTERNATIVE A (Present/35' Van)[1]

This alternative represents one of the two methods by which lettuce is currently transported from the CONUS West Coast to Europe. With this method lettuce is loaded without pallets into a precooled refrigerated trailer with normal atmosphere and transported by truck to the East Coast. On the East Coast the lettuce is transloaded in a 35' refrigerated van container for ship transport to Europe.

[1]If most lettuce is currently transloaded into Sealand M-10 Vans for ocean transport, this alternative will be deleted.

ALTERNATIVE B (Present/Sealand M-10 Van)

This alternative represents the second of the methods by which lettuce is currently transported to Europe. The only difference between this alternative and Alternative A is that the lettuce is loaded into an M-10 Van rather than a 35' Van on the East Coast for ship transport to Europe. The M-10 Vans are newer and have larger, more accurate temperature control units than the 35' Vans.

ALTERNATIVE C (Improved Present/Sealand M-10 Van)

Under this alternative the lettuce is transported from the CONUS West Coast to East Coast in the same type of precooled refrigerated trailer with normal atmosphere utilized for Alternatives A and B. However, in this alternative pallets are utilized and the lettuce is loaded, spaced, and braced to improve air circulation. The proper loading pattern and the number of cases per trailer for this alternative will be determined by USDA/DLA prior to the start of the test. On the East Coast the lettuce is transloaded into a M-10 Van for ocean transport. The M-10 loading pattern for this alternative is the same as in all previous alternatives.

ALTERNATIVE D (Modified Atmosphere - Tectrol)

Under this alternative a precooled Sealand M-10 Van is source loaded at the CONUS West Coast for through transport to Europe. No transloading from one container to another is required on the East Coast. At the source a one time charge of Tectrol is added to the van till the oxygen level is reduced to $3 \pm 1\%$ at which time the van is sealed for transport. Depending on how "tight" the van seal is, the controlled atmosphere may be lost during transit.

ALTERNATIVE E (Normal Atmosphere)

This alternative is the same as Alternative D except that no Tectrol is added at the source to replace oxygen.

ALTERNATIVE F (Controlled Atmosphere - Nitrol)[2]

Under this alternative a precooled Food Source, Inc. container is also source loaded at the CONUS West Coast for through transport to Europe without transloading on the East Coast. The primary difference between this alternative and Alternative D is that this van has atmosphere monitoring equipment and a liquid nitrogen tank to add nitrogen gas as required to maintain the desired controlled atmosphere. In addition, this van must be transported from the West Coast to the East Coast by rail due to the excessive weight of the van. This requirement may add one day transit time from the West Coast to East Coast as compared to Alternatives A through E.

[2]Or other equivalent continuously metered and monitored controlled atmosphere system.

IV. EXPERIMENTAL DESIGN

A. DATA COLLECTION PERIOD

Approximately six months of data collection are required. This requirement is based upon the current European lettuce shipment quantities, the number of alternatives to be evaluated (6), and the desired accuracy in the estimate of the spoilage rate for each alternative.

B. DESIRED ACCURACY

Based upon current system spoilage data, a minimum of 20 containers for each alternative are required to insure with 95% confidence that the average measured spoilage rate for each alternative is within 2.5% of the alternatives "true spoilage rate".

C. SAMPLING PLAN

The alternatives were selected to measure the impact of various CONUS West Coast to East Coast transport alternatives, the impact of through shipment compared to East Coast transloading, and the impact of various ocean transport alternatives on spoilage rates. The number of alternatives to be evaluated was limited to six since only six to seven containers of lettuce are currently transported to Europe weekly. Therefore, each week six van container loads are desired, one loaded and transported according to each of the six alternatives. If less than six loads are to be shipped in any given week they should be loaded according to the following priority.

1. Alternative D
2. Alternative E
3. Alternative F
4. Alternative B
5. Alternative C
6. Alternative A

A minimum of four container/van loads are required in any given week.

D. SPOILAGE DATA

To evaluate the cost effectiveness of alternatives, cumulation spoilage rates to the time of consumption need to be estimated. To maintain control over the data collection procedures all spoilage data will be collected at Kaiserslautern. Therefore to estimate the spoilage rates to the consumer level, the handling and distribution of lettuce from KCS to the typical consumer will be simulated at KCS and spoilage data taken at three points in time: incoming inspection, three days later, and six days later. The simulation plan for the handling, distribution, and treatment of lettuce from KCS to the typical consumer needs to be developed with input by KCS, DSR-E personnel.

However, once established thirty cases of lettuce will be required from each van for this purpose, to include 9 from the front, 12 from the middle, and 9 from the back of the van. From these 3, 4, and 3 will be selected respectively, from the front, middle, and back for each time sample referenced above.

E. TEST SCHEDULE WITH MONITORING EQUIPMENT

The ORSA office, in conjunction with USDA, R&D Labs, Fresno, CA, will arrange to collect additional environmental control data by placing monitoring devices in some of the shipments. Three sets of monitoring devices are available. The time from placement in a van until they are returned is estimated at about 3½-4 weeks. Therefore the devices will be placed in vans every four to five weeks. These devices are designed to continuously record internal container time temperature profiles.

The six alternatives involve only three different types of containers/trailers for West Coast to East Coast service (trailer, Sealand M-10, Food Source Nitrol) and three different types of ocean containers (Sealand 35', Sealand M-10, Food Source Nitrol). Therefore the monitoring devices will be placed in the following three alternatives.

Alternative F (Controlled atmosphere - Food Source Nitrol)

Alternative D (Modified atmosphere - Sealand M-10 Tectrol)

Alternative A (Trailer, Sealand 35' - Van Container) if not used then

Alternative C (Trailer, Sealand M-10 Van Container)

F. EXPERIMENTAL CONTROLS

The purpose of this evaluation is to measure the relative impact of various West Coast to East Coast transport alternatives, through transport versus East Coast transloading, and various ocean transport alternatives on lettuce spoilage. However, many other factors also impact lettuce spoilage, for example the weather, seed variety, time from picking to cooling, truck/van condition, etc. To minimize the potential for varying effects on lettuce spoilage rates due to these factors, and to increase the validity of the relative spoilage data for each alternative, these factors will be controlled to the maximum extent possible as follows:

1. For a given weeks shipment all lettuce will be from the same field and the same seed variety, and will be picked the same day. In addition all lettuce will be treated the same from time of picking to vacuum cooling to include elapsed time.

2. To remove the effect of wrapped versus naked lettuce on each alternatives' spoilage rate, all cases utilized to establish an alternative's spoilage rate for any given week will be either all naked lettuce or all wrapped lettuce. Based on the lettuce orders DLA will make this determination on a weekly basis and insure that a sufficient number of cases of naked or wrapped lettuce are placed in each van/trailer to determine spoilage data at KCS.

3. The USDA inspector will inspect the lettuce and monitor the West Coast trailer/van container loading process to insure that the lettuce loaded into each van is of comparable initial quality. In addition all trailer/van containers will be checked to insure all have been precooled to the proper temperature.

4. Alternatives A, B and C utilize the same type of precooled refrigerated trailer for West Coast to East Coast movement. The DLA will make the ncessary arrangements and perform the ncessary inspections to make sure that these three trailers are of comparable quality throughtout the test period. In addition the DLA will insure that the Sealand M-10 Vans for Alternative D and E are of comparable quality.

5. Alternatives A, B and C require transloading from one container to another on the CONUS West Coast. To minimize varying effects on each alternatives' spoilage due to this factor all three containers shall be transloaded the same day, one after the other to minimize the effect of different ambient temperatures. In addition, DLA will monitor the transloading process to insure the following: all transload times are comparable and close to some average or expected time, all vans are of comparable quality, and all vans have been precooled to the proper temperature.

6. DLA will make the necessary arrangements to insure that all containers are loaded onto the same vessel for ocean transport. From the CONUS East Coast to KCS all containers will be handled/transported the same way.

7. All lettuce spoilage data will be collected at KCS (see section IV-D). DLA will designate the KCS personnel and insure that all spoilage data is collected and determined based upon rigid specifications. As stated in paragraph IV. D thirty cases 9 from the front, 12 from the middle, and 9 from the rear of each van are required for this purpose. The cases must be drawn randomly and numbered as follows:

Trailer/Van No._____

Case No._____

The cases as drawn will be numbered as follows: front nine, 1 through 9 consecutively; middle twelve, 10 through 21, and back nine, 22 through 30. Cases utilized to determine spoilage rates for each time point are as follows:

Inspection	Case No.
Incoming	1,4,7,10,13,16,19,22,25,28
3 days later	2,5,8,11,14,17,20,23,26,29
6 days later	3,6,9,12,15,18,21,24,27,30

Spoilage data for each van/container at each point in time will be summarized on a NLABS data collection form.

All of the above experimental controls must be implemented to minimize the potential for varying effects on each alternative's spoilage rate due to factors outside the scope of this evaluation plan.

G. DATA COLLECTION SYSTEM

Four separate data collection sheets (see appendices) have been developed to be used in conjunction with produce condition reports and inspection certificates presently being prepared for DLA Quality Assurance Activities. The West Coast segment can be prepared through the cooperative effort of the DLA buyer and USDA inspector. The East Coast segment can be prepared by Government acceptance inspection personnel. The European segment can be prepared by personnel tasked with arrival inspection at KCS. The spoilage data summary sheet (appendix #4) will be used to collect spoilage loss information to the consumer level by simulating at KCS those events occuring from the arrival of lettuce at KCS until it is actually served in the dining facilities or resale occurs in the commissary. The inspection time points on the data sheet of the 3rd and 6th day are estimates and may need to be changed when a representative sampling of actual time has been reviewed and discussed with DSR-E personnel.